DOCUMENT RESUME

ED 131 639 EC 091 852

AUTHOR	Kafafian, Haig
TITLE	DEBLICOM: Deaf-Blind Communication & Control Systems: First Quarterly Progress Report.
INSTITUTION	Cybernetics Research Inst., Inc., Washington, D.C.
SPONS AGENCY	Rehabilitation Services Administration (DHEW), Washington, D.C. Office of Human Development.
PUB DATE	76
GRANT	23-P-57488/3-04
NOTE	58p.
EDRS PRICE	MF-$0.83 HC-$3.50 Plus Postage.
DESCRIPTORS	*Codification; *Communication (Thought Transfer); Communication Problems; *Cutaneous Sense; *Deaf Blind; Multiply Handicapped; *Sensory Aids
IDENTIFIERS	DEBLICOM

ABSTRACT

Reported on is the first phase of development of DEBLICOM, a code for a two-way communication system for deaf-blind individuals who may be speech-impaired. Brief sections cover the following topics: alternatives to and considerations for the development of cutaneous codes for deaf-blind people; the DEBLICOM system which provides a means of receiving information through a portable programing device and of transmitting information by means of keying an interface which is part of the equipment; the concept of dual-coding as related to the DEBLICOM system; seven coding considerations (which include a design which permits use for social communication purposes); the methodology involved in testing the discrimination of cutaneously applied vibratory stimuli of a test code with 18 Ss; an introduction to the Morse code; possible ambiguities of the six-dot Braille code; and future activity plans (such as conducting in depth studies of alternative codes). Appended are working papers which include information on the background of the DEBLICOM; the population of deaf-blind individuals in the United States; and some causes of deafness-blindness, deafness, and blindness. (SBH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

Cybernetics Research Institute

ED131639

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

C/R/I

FIRST QUARTERLY PROGRESS REPORT ON

DEBLICOM

DEAF-BLIND COMMUNICATION & CONTROL SYSTEMS

GRANT NO. 23-P-57488/3-04

Submitted to

REHABILITATION SERVICES ADMINISTRATION
OFFICE OF HUMAN DEVELOPMENT
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

By

CYBERNETICS RESEARCH INSTITUTE
Washington, D. C.

EC091852

"PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY
Rose Kafafian

TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER."

Haig Kafafian
Principal Investigator

Grantees undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official position or policy of the Rehabilitation Services Administration.

This report contains proprietary information and copyrighted material and may be released by the United States Government to the public, provided that the appropriate copyright notice is applied thereto (except by reviewers for the public press). Copyright on these materials is claimed only during the period of development, test and evaluation unless authorization is granted by the Rehabilitation Services Administration to claim copyright also in the final materials. For information on the status of the copyright claim, contact either the copyright proprietor or the U.S. Government.

Copyright © 1976
by
Cybernetics Research Institute
Inc.
2233 Wisconsin Ave., N.W., Washington, D.C. 20007, Tel. 202-333-4112.

CONTENTS

Preface i

I. INTRODUCTION 1

II. DEBLICOM 5

III. DUAL-CODING 9

IV. CODING CONSIDERATIONS 12

V. METHODOLOGY 15

VI. MORSE CODE 24

VII. BRAILLE CODE AMBIGUITIES 32

VIII. FUTURE ACTIVITY PLANS 34

Appendixes

A. Selected C/R/I DEBLICOM Working Papers
1. Transfer of Training
2. Considerations for Cutaneous Stimuli
3. Usher's Syndrome
4. Conferences on DEBLICOM

Figures

1A. Stimulated Positions - Condition A
1B. Stimulated Positions - Condition B (Front)
1C. Stimulated Positions - Condition B (Back)
1. Matrix of Confusabilities

2. Two-Dimensional Configuration
Multidimensional

Figures (cont.)

3. Relation Between Mean Percent "Same" Judgment And Interstimulus Distance

Tables

I. Trial Presentation Schedules
II. C/R/I Dual-Input DEBLICOM Random Number Matrix
III. Possible Ambiguities in the 6-Dot Braille Cell

Charts

I. Morse Codes
International Code
Cable Code
American Code

PREFACE

This First C/R/I Quarterly Report describes continuation of a research program under Grant No. 23-P-57488/3-04 for the period November 15, 1975 to February 15, 1976 for the REHAPILITATION SERVICES ADMINISTRATION, OFFICE OF HUMAN DEVELOPMENT, DEPARTMENT OF HEALTH, EDUCATION AND WELFARE, entitled DEBLICOM (Deaf-Blind Communication System).

This portion of the program covers the first phase of the development of a suitable code for a two-way communication system (DEBLICOM) for use by persons who are deaf-blind and who may be speech-impaired. The report also covers the first phase of a study of alternative codes in theoretical depth.

I. INTRODUCTION

The coding of information for communications purposes is primarily a human accomplishment whereby stimuli of discernible objects, events, and ideas are represented by a family of elements of a coded language which although representative of the stimuli do not necessarily share their physical properties. "What is information, and how is it measured? One of the simplest most unitary forms of information is the recording of a choice between two equally probable simple alternatives, one or the other of which is bound to happen-- a choice, for example between heads and tails in the tossing of a coin. We shall call a single choice of this sort a decision". (Weiner, 1948)*. Although the example Weiner cites does not consider the third side of the coin the basic concept of information remains as one where at least two alternatives are present. Moreover, accuracy, stability, and reproducibility are characteristics essential to the processing of information where responses to choices prevail, be it a living or non-living system.

In a living system, the awareness of stimuli through our sensory systems depends not only on the effectiveness of the body sensors, but also upon the individual's cognitive ability to discern and select elements of the stimuli and associate them to their appropriate referents. "It becomes information when a living or non-living system acts on it". (Kafafian, 1971). ** The acts of making choices or decisions can take place effectively only when

* Weiner, N., "Cybernetics", Wiley & Sons, Inc., New York, 1948
** Harrell, T., "Cybernetics and Data Processing in Advanced Technology Systems Concepts", ed. M. Rubin. New York; Averback, 1971.

the elements of the language are unequivocal and their representation unambiguous. We know that this is not the case with all elements of the approximately 3,000 languages that are in use. Consequently, one problem that will prevail, even after adopting a suitable, unequivocal code is that this code will be related to other coded languages which are equivocal. One unequivocal code proposed for use by blind persons who do not use Braille or find it too difficult to learn is HAIBRL, a punctographic system rich in unambiguous patterns. Another is the dual-input/output cutaneous "Cybertac" code as used in DEBLICOM for persons who are deaf-blind.

In the development of cutaneous codes for use by deaf-blind persons, one must include in their considerations the assignment of unambiguous meanings to the coded elements. The following temporal and/or spatial, digital and/or analogue means are representative of methods and codes employed by man for communication purposes. They are shown with the principal sensory modes associated with their use.

a) Phonemic speech - (Auditory and Kinesthetic)
b) Graphic and ideographic cursive writing or printing - (Visual & Kinesthetic)
c) Music - (Auditory, Cutaneous and Kinesthetic)
d) Choreography - (Kinesthetic, Visual, Auditory and Cutaneous)
e) Morse Code - (Auditory, Visual, Cutaneous and Kinesthetic)
f) Semaphore Code - (Visual and Kinesthetic)
g) Manual Sign Langauge - (Kinesthetic, Visual and/or Cutaneous)
h) Braille or HAIBRL - (Cutaneous and Kinesthetic)
i) Lip Reading - (Kinesthetic and Visual)
j) Tadoma Method - (Kinesthetic and Cutaneous)
k) Body Language - (Kinesthetic, Visual, Auditory and Cutaneous)
l) Man-Machine Methods, e.g., "Optacon", "Stereotoner", "Optaphone" " Vibratese", "Cybertac", "Optohapt", "Tally-Optohapt", "Code-Com", Video to Tactile and Audio to Tactile Systems - (Kinesthetic, Visual, Auditory and Cutaneous)

This list includes methods for one-way and two-way communications for use by persons having diminished or total loss of certain sensory capabilities. Persons with sensory dysfunctions having healthy minds and the innate ability to acquire languages are compelled to use these present methods, many of which are inadequate, ambiguous, and extremely difficult to learn. None of the methods or codes is applicable for general two-way communication purposes for individuals who are deaf-blind who wish to establish social communications with the general public. In addition, the average person does not realize that few persons who are blind can use Braille effectively (less than 10%), and that "lip reading" and "signing" are known principally by individuals associated with deaf and/or speech-impaired persons. The fact that people may be acquainted with the applications of telegraph and radio codes does not mean that the general public is prepared to learn them for purposes of daily communications. It is also recognized that often non-disabled individuals are reluctant to establish body contact such as required in simple "body-writing".

But the fact remains that all of the foregoing coded language schemes used by persons with sensory losses are not acceptable by the public for their use in social communications with this growing segment of the disabled population.

These are constraints that cannot be dismissed and they present serious problems toward providing deaf-blind persons with viable two-way communication means for general two-way communication purposes. What then is the direction toward developing a suitable code to serve this segment of the population? Since the beginning of language, codes have intrigued man, but as Kahn (1967) has noted: ".... men cannot even read the primitive Mayan hieroglyphs or the Voynich manuscript, and the simple process of translation from one common language to another still plagues the cause of peace. If this be so between individuals of the same species inhabiting the same planet, how difficult would it be to communicate with an utterly different species having nothing in common with man and living on a planet invisible to him!" *

Let us then continue our reflections on the establishment of coded languages to serve the two-way communications needs of individuals who share our very innate human cognitive abilities but who are deprived of the sensory capabilities of sight and hearing.

Our assumption is that we can, through use of available technology, develop an appropriate language coded to suit persons who are deaf-blind and who may be speech-impaired and also acceptable to the general public. This work is directed toward that goal.

* Kahn, D., The Code Breakers, The Story of Secret Writing, The MacMillan Co, N 1967.

II. DEBLICOM

DEBLICOM is a cutaneous communication system designed for use by persons who are deaf-blind and for persons who do not have training in special language codes. Information is received by means of palpable vibrations on the user's body through a portable programming device. Transmission of information is accomplished by means of keying an interface which is a part of the equipment.

Dual-coding is basic to each element of the transmitted and/or received coded language. (A State 1 condition). The application of dual-coding first appeared in 1967; subsequently severely disabled children were taught how to operate typewriters having either 14 keys, 7 keys, or one-key or transducer e.g., microphone and myoelectric pick-ups. Ordinarily typewriters have about 49 keys but since these children could not write or use a standard 49-key keyboard they were taught to operate simplified "reduced-key" dual-code interfaces. One of the first cutaneous communication systems that used the dual-code was the "Cybertac" system;* its dual-coding is basic to the one proposed in the present DEBLICOM system. In "Cybertac", a two-way keyboard was proposed for both programming and receiving information, also means were provided to receive the palpable vibrations not only on the fingers but also on the body.

* Kafafian, H., "Study of Man-Machine Communications Systems for the Handicapped", Washington, D. C., C/R/I Interim Report (1968).

Thus, the new DEBLICOM system is designed for use with the somesthetic senses through use of a dual-coded cutaneous and/or subcutaneous stimulation scheme not unlike the original "Cybertac" system, except that additional outputs have been added including one in the form of artificial speech. In one embodiment using a "reduced-key" bilateral keyboard divided into two banks, the output is responsive to a dual-input code. Activation of two vibrators at positions on opposite coordinates on the body, be they symmetrical or asymmetrical, represent an element of a two-input code. Significantly, all elements of the code are programmable by the deaf-blind person's fingers using the bilateral dual-input interface and for the non-handicapped person a standard keyboard is used. Concepts, events, symbols, such as letters of the alphabet, or functions of a machine can be represented in this manner for two-way communication purposes.

But before going into operational details there are social questions to which we must address ourselves, not only because (except in isolated cases) today's deaf-blind persons have limited communication means but an increase in this segment of the disabled population over the next few decades is expected. (See C/R/I Working Paper on Usher's Syndrome, Appendix A). In any case there is no compromise, for society is compelled to seek solutions and assign a fair share of its resources to develop viable systems which utilize the remaining capabilities of these individuals, particularly

their somesthetic systems. The first step is that we must develop and test an unequivocal code that is compatible to the languages in use. Hence, returning to DEBLICOM, the awareness of the needs of persons who are deaf-blind and the need to develop a system and build the necessary hardware must first be acknowledged. Once this plan has been accepted we may proceed with the development of training materials and consideration of other languages and codes which are compatible to the remaining perceptual, motor and cognitive abilities of the human controller. To establish and enhance message transmission and reception to and from the deaf-blind controller the codes selected must be compatible with the individual's psycho-motor sensory capabilities and introduced at the earliest stage of awareness of any severe auditory and/or visual sensory disabilities. Today we have at our resources technologies that offer solutions to problems at hand and extensive scientific knowledge of "Cybernetics, the science of control". (Bigelow)*

We know that perceptual detection and recognition of coded information is critical not only in the reception but also in the transmission of a message. "For example, the act of speaking requires auditory feedback of speech sounds and tactile-kinesthetic feedback from the vocal musculature to assure intelligible continuity and enunciation of speech. Similarly, the act of signing by the hearing-impaired requires visual

*Bigelow, J. & Kafafian, H. - Private Communication (1968).

and kinesthetic feedback to provide the signing individual with information about the positions of his hands and fingers. This information feedback, essential for the transmission of a message, is itself coded to specific elements or meanings or referents. Consequently, for an individual to both transmit and receive a message, at least two different kinds of coded sensory information must be differentiated and comprehended.

"In the case of message reception, coded stimulus information is picked up by the perceptual systems and associated with assigned meanings or referents. The transmission of a message requires that meanings or referents be associated with specific bodily movements or acts which are controlled through sensory feedback". (Reynolds, 1970)*

For an excellent overview on cutaneous means of communication, the attention of the reader is directed to Sherrick's** "Current Prospects for Cutaneous Communications". To the thoughts expressed, we can add that even though an individual does not have hearing and visual capabilities as long as he has a healthy mind and acceptable behavior and motivation he can be taught by competent and dedicated teachers how to use his other sensory systems for two-way communications purposes.

* Reynolds, H., (1970),"Coding of Sensory Information in Communication Systems for the Handicapped". A paper on work performed at C/R/I presented to the symposium on "Coding of Sensory Information for Artificial Human Communication Systems", Annual Meeting of the American Psychological Association.

** Sherrick, C.E., "Current Prospects for Cutaneous Communication". Paper presented at the Conference on Vibrotactile Communication, Austin, Texas, 1974.

III. DUAL-CODING

One embodiment of a dual-coding system as proposed for use by persons who are severely disabled was described in U.S. Patent No. 3,507,376 "Communications Systems for the Handicapped". That dual-coding system used a 14-key keyboard and included an arrangement of the English alphabet according to its frequency of usage. Subsequently, 7-key interfaces were employed using the dual-input code in U.S. Patent No. 3,831,147. In addition, U.S. Patent No. 3,798,599 disclosed a dual-coding system operable by a single key which is used to operate environmental controls, typewriters, voice synthesizers, and so on. As previously mentioned, dual-coding has been in use since 1967, when its first applications appeared with "Cybertype",® a remotely controlled typing machine used by severely disabled children who were unable to write or use a standard typewriter keyboard. These systems are in present use mainly at C/R/I Field Centers in the United States.

Data covering these early programs at the C/R/I Field Centers and recent evaluations of systems using the dual-coding have been reported in the literature (BEH 1968, 1970, 1971)* and in a National Academy of Sciences (CPRD) clinical study which was supported by RSA (report in NAS press).

* Kafafian, H., "Study of Man-Machine Communications Systems for the Handicapped", Washington, D.C., C/R/I Reports

® Cyber Corp., Washington, D.C.

In order to better understand one manner in which dual-coding is used, let us assume use of a 10-key keyboard where operation of two keys at a time produces a letter. Thus in this configuration 25 outputs are available by simultaneously striking two keys, one key from each side of the 10-key keyboard. This method of programming or keying may be identified as "bilateral simultaneous programming".

This concept of dual keying or programming is proposed for use in DEBLICOM for many reasons. One being that there are reduced problems in rapidly locating the correct keys. Moreover, in a system similar to the "Cybertac" described earlier where the outputs are palpable vibrations, we can, with a 10-key keyboard and ten vibrators located on the body, produce 45 separate dual-outputs from the 10 keys. In this case all dual-keying fingering positions are used and 45 dual inputs are available for the keyboard, rather than 25 as cited earlier with bilateral programming. Thus with five of the vibrators located on the left side of the body and the other five on the right side, all outputs are under the control of the operator's fingers. Each output is associated with a discrete pair of finger combinations. See Appendix A, C/R/1 Working Paper "Transfer of Training".

There are also features of dual-input keying arrangements which are desirable for deaf-blind persons with spastic conditions since, unlike

a standard keyboard where the uncontrolled striking of a key produces spurious letters, certain configurations of the dual -keying arrangement minimizes or eliminates this problem.

The dual-keying arrangement can, in the case of a 16-key keyboard, permit unambiguous palpable dual-outputs. This arrangement can be considered a Grade 1 or a State 1 condition. Redundancy has been covered in the previous C/R/I DEBLICOM Report. As for outputs, they can be palpable vibrations on the body as proposed in DEBLICOM and/or in the form of visual display, print, Braille or synthesized speech for persons with whom the deaf-blind persons are communicating. But before going into these areas, let us introduce the DEBLICOM coding considerations which follow.

One may note that the 120 unambiguous outputs are the same for HAIBRL, the two-dot punctographic system which was designed for persons who cannot use Braille. This relationship here is for future considerations of codes and stimulator locations for blind persons who may use HAIBRL and who may later lose their hearing capability.

IV. CODING CONSIDERATIONS

The following are considerations for use in a two-way cutaneous communications system.

1. The suitable code must have sufficient discriminability and capacity so that it can be taught to persons who have no visual and auditory sensory capability but who have sufficient cognitive and learning abilities for the acquisition and comprehension of coded language.

2. The suitable code must be capable of being presented on or beneath the surface of a person's body through means of palpable vibrators or stimulators which can be easily coupled to or attached and removed from the user.

3. The suitable code must have the capacity of handling all alphabet and symbols of any Indo-European language and, where applicable, basic symbols of ideographic languages. It must also have sufficient elements or code members to serve each controlling function as required; writing machine and devices, e.g., typewriters, environmental controls, and computer terminals (for use by the homebound). Ambiguities will not be permitted, i.e., each state of the coded language is assigned to only one letter function, concept or ideograph and so on. Coding schemes with multiple meanings are not allowed such as those encountered in the Braille code where due to pattern limitations more than one meaning is assigned for each pattern (of a total of 63), thereby resulting in potential ambiguities,

especially if the context in which the pattern is used is not understood.

4. The suitable code must be designed to permit use for social communication purposes, that is, with people who have no special training or knowledge of language codes other than an ability to use (read & write or type) and comprehend every-day language in a regular manner. (see item 5)

5. The suitable code must have the property of not requiring special training for interpreting the transmitted information by persons not disabled. Thus persons who are deaf-blind having language and cognitive capabilities may use the code with non-handicapped persons who do not have any training but who have cognitive and language comprehension.

6. The suitable code must be of that nature whereby users require no personal physical contact to or from another person in either the transmitting or receiving modes.

7. The suitable code must be capable of being interfaced with electromagnetic, sonic and/or acoustic communications and control systems and be compatible with their signal-to-noise and bandwidth characteristics.

In addition to the requirements in Item 1 through 7 the codes must be compatible to devices such as:

a) Readout devices, e.g., typewriters and visual displays which can be read by the sighted.

b) Audio devices, e.g., speech synthesizers or systems with audio outputs which can be heard by persons with hearing capabilities. (See C/R/I DEBLICOM Interim Report, 1975)

c) Tactile or palpable devices with outputs in punctographic form, e.g., the Cyberbrailler, the Perkins mechanical Brailler or the Perkins electric Brailler by Friedman*(1975) which can be used by persons with Braille reading and writing capability.

d) Cutaneous and/or subcutaneous transducers for tactile detection for use by persons having tactile sensory capabilities on that portion of the body below the head.

As it can be discerned, four additional requirements have been addended to the seven basic code considerations. It follows that before we can proceed to realize fulfillment of these requirements a procedure should be developed for the purpose of determining the deaf-blind person's ability to detect and discriminate coded paired body stimuli.

* Private Communication - Kafafian, H., and Friedman, H., Perkins School for the Blind (1975).

V. METHODOLOGY

Experimental Determination of the Usefulness of Body Coordinates when Stimulated through TEBLICOM Deaf-Blind Communications Tactile Display

This section deals with that portion of the program involving testing of codes, in particular the discrimination of cutaneously applied vibratory stimuli of a test code. A total of 18 subjects will be engaged in the tests with seventeen of the subjects from two deaf-blind institutions in the United States and one deaf-blind consultant/subject from the Library of Congress. Ten of the subjects are at the Alabama Institute for the Deaf-Blind and seven are from the National Center for Deaf-Blind Youths and Adults.

The training of test administrators for the subjects engaged in the program will be accomplished by C/R/I staff in cooperation with qualified professional personnel at the participating centers who work with the subjects on a daily basis. For the purpose of obtaining feedback, all subjects must have a means of articulating prior to their acceptance in this study. They must also have the ability to maintain practical operational periods of attention to the prescribed experimental tasks.

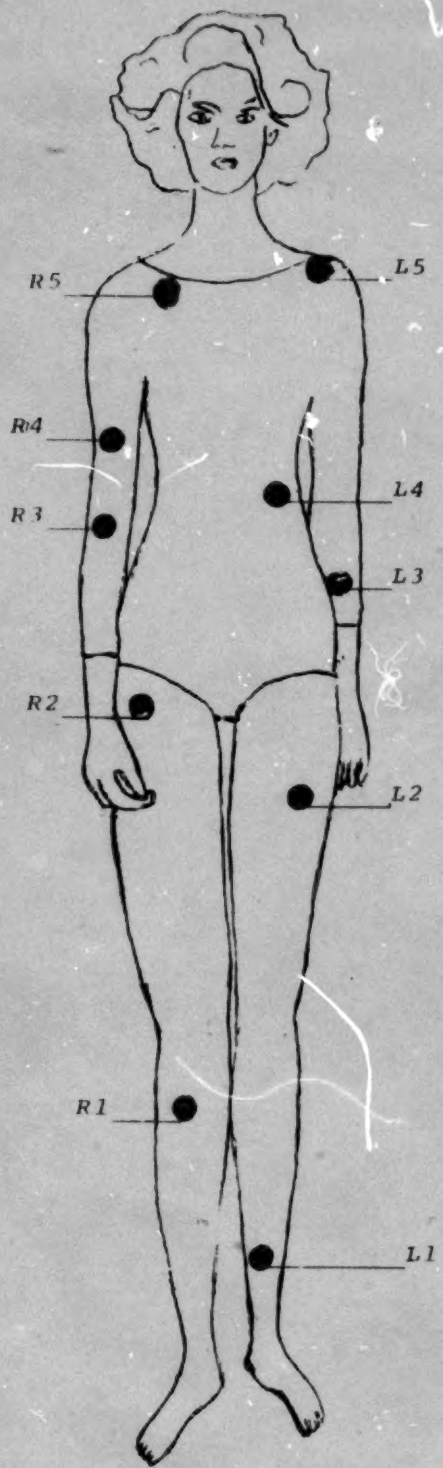
Portions of the "C/R/I Capability Inventory Form" and the "Physical Assessment and Subject Identification Form" (See Appendix B).* will be used to collect information on the subjects, such as the date of their entry into the program, sex, age, clinical description of disability, extent of academic capability and so on.

* Available to research centers from C/R/I.

The following procedures describe experiments which will provide information relevant to the development of the DEBLICOM code and the positioning of the cutaneous stimulus transducers. The purpose of the experiment is to assess the extent to which the body's axes and planes can be used to reduce localization ambiguities of tactile displays. The stimuli to be tested and compared consist of two sets, the control and the experimental sets. The experimental set, Condition B, (see Figure 1B & 1C) consists of stimuli placed arbitrarily on the body in locations similar to the control set, Condition A, (see Figure 1A) as used by Geldard and Sherrick (1965). Comparison of Figure 1A with Figure 1B & 1C will show that the experimental set will be at the control set's loci except all of the right side stimulator positions are posterior rather than anterior.

The experiment will be an economical attempt to obtain body coordinate discriminability information in tactile displays in the assessment of a dual-input code. Two hand-held stimulators* (Model DBS) or rods are to be used by the experimenter. They are applied to preselected sites, so that the stimuli will reach the surface of the skin of the subject's bodies (whether applied directly to the skin or through clothing). Two bilateral stimuli will be presented simultaneously thereby conforming to the basic dual-coordinate DEBLICO coding. Thus for each pair of coded functions, one stimulus will be applied to the left side of the body and the other stimulus simultaneously to the right side.

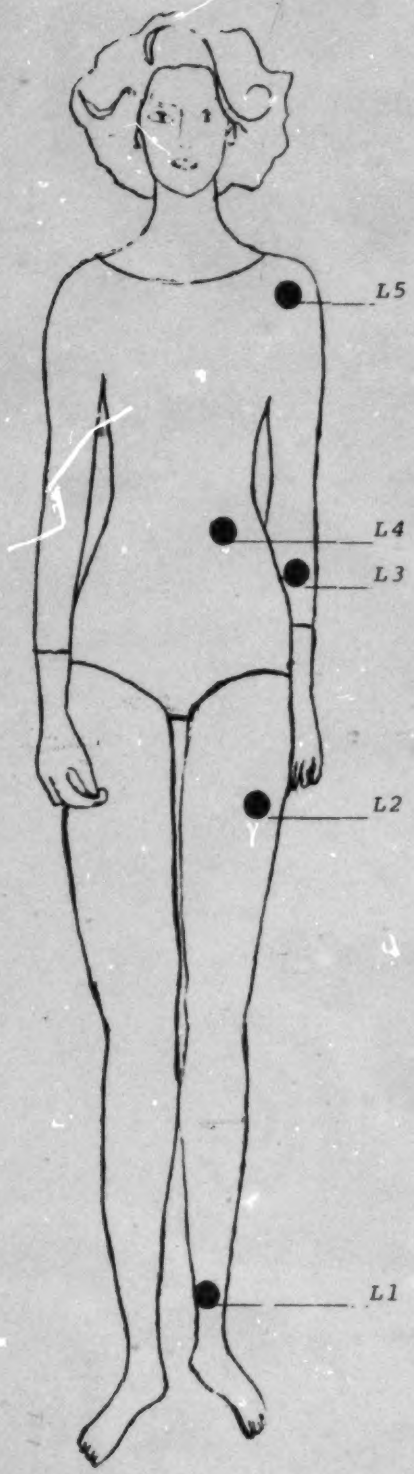
*Supplied by C/R/I.



Positions of Stimulation

R1-shin	L1-ankle
R2-upper thigh	L2-lower thigh
R3-mid forearm	L3-wrist
R4-above elbow	L4-waist
R5-chest	L5-shoulder

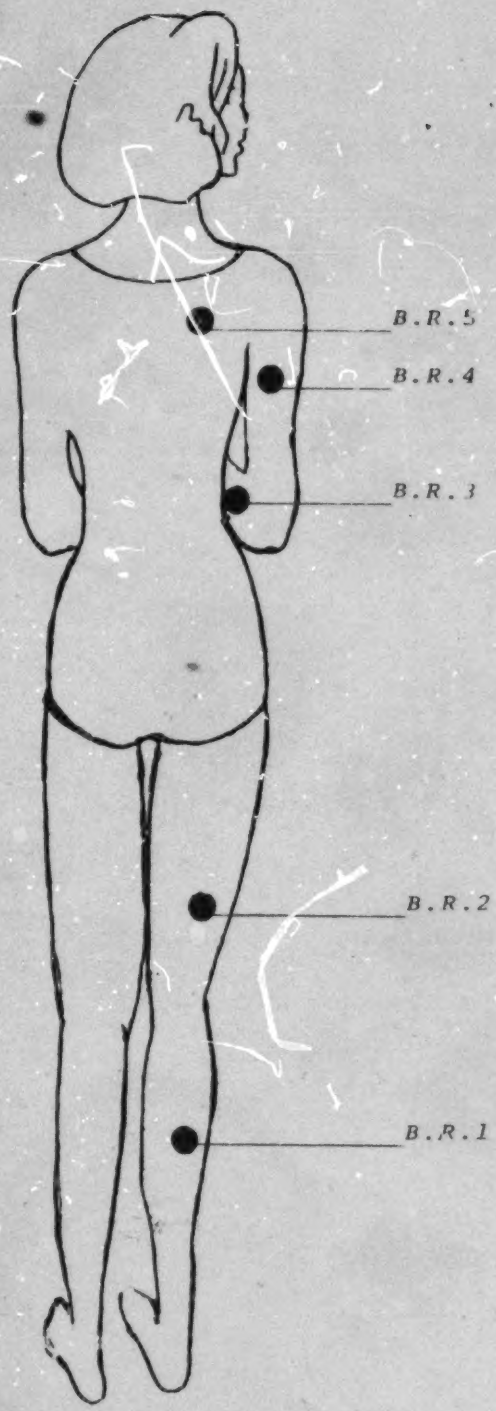
Figure 1A - Stimulated Positions - Condition A



Positions of Stimulation

L1-ankle
L2-lower thigh
L3-wrist
L4-waist
L5-shoulder

Front Figure 1B - Stimulated Positions - Condition B



Positions of Stimulation

B.R.1-calf
B.R.2-upper thigh (posterior)
B.R.3-forearm (posterior)
B.R.4-above elbow (posterior)
B.R.5-shoulder blade

Back Figure 1C - Stimulated Positions - Condition B

A trial will consist of two sets of paired stimuli presented sequentially, one pair immediately following the other. The subject's tasks will consist of informing the experimenter in a mutually agreed upon manner as to whether or not the second pair of stimulus presentations (body positions) was at the same or at different locations as the first paired presentation.

Numbers 1 through 5 will be assigned to the five positions on each side of the body, e.g., L1 through L5 for the left side and R1 through R5 for the right side. Thus ten body positions are used. A sequence of pairs of dual-input pairs has been compiled (See DEBLICOM Scoring Sheet 1A in Appendix C).* In the tabulation the first numeral in each pair corresponds to the right stimulus position and the second numeral to the left position. Each pair of stimuli are combined only once with every other pair including itself. Exactly 625 test trials are required to exhaust the combinations in the random-order matrix of Table II. One hundred training trials and the 625 test trials are to be divided into three separate sessions. (See Table I)

* Available to research centers from C/R/I.

Trial Presentation Schedules

Session	Training/Trials	Test/Trials
I	100	125
II	0	250
III	0	250

Table I

Table I indicates the three session segments and the training/trial and test/trial breakdown of the trial presentation schedules. Table II on the following page is the random number matrix from which DEBLICOM 1A Scoring Sheets (See Appendix B)* were compiled. A kit including a supply of Scoring Sheets will be provided to the field centers participating in the program.

* Available to research centers from C/R/I.

FIRST DUAL-INPUT PAIR

SECOND DUAL-INPUT PAIR

	1-1	1-2	1-3	1-4	1-5	2-1	2-2	2-3	2-4	2-5	3-1	3-2	3-3	3-4	3-5	4-1	4-2	4-3	4-4	4-5	5-1	5-2	5-3	5-4	5-5
1-1	358	90	496	80	71	113	355	119	269	171	132	622	451	504	92	82	291	210	582	417	613	321	522	237	10
1-2	371	254	536	424	329	563	539	127	179	409	395	89	505	227	252	250	83	91	14	287	203	265	33	503	377
1-3	387	401	184	284	263	104	328	292	334	63	225	561	432	306	326	240	469	345	307	408	515	380	283	574	267
1-4	26	256	110	436	566	607	517	151	34	478	253	180	428	579	17	87	140	115	407	391	77	400	379	513	206
1-5	533	286	195	305	476	18	7	101	331	244	259	618	134	541	410	537	218	105	85	278	356	215	341	593	204
2-1	528	169	453	2	285	15	525	191	74	220	388	457	406	228	301	527	518	602	397	543	75	450	480	573	93
2-2	487	445	149	125	41	611	133	95	103	279	242	164	412	154	411	193	177	502	112	318	420	309	209	621	419
2-3	24	392	557	150	471	545	571	153	298	390	173	548	372	271	281	404	172	5	509	229	293	349	114	614	484
2-4	534	507	43	568	123	619	590	167	463	257	219	597	457	327	359	289	559	118	461	564	429	312	494	464	402
2-5	475	474	423	481	592	454	576	347	239	414	131	20	67	4	236	222	553	294	12	198	40	296	333	605	396
3-1	421	497	61	558	70	302	351	188	544	36	48	280	472	477	194	538	310	353	600	186	393	470	500	208	449
3-2	156	141	512	555	31	508	72	49	224	624	493	598	299	546	161	569	521	98	59	146	138	130	212	586	373
3-3	174	183	560	448	492	276	162	13	433	337	620	516	197	519	344	364	272	587	368	604	270	96	572	136	258
3-4	23	313	459	27	238	567	102	383	374	57	483	565	311	583	431	382	357	588	336	570	200	426	524	440	367
3-5	531	361	64	317	62	11	38	88	142	73	217	398	190	581	21	201	575	405	22	94	168	46	584	551	47
4-1	32	447	178	189	29	251	441	418	495	226	596	137	231	300	255	274	66	335	176	529	460	549	540	625	261
4-2	485	438	185	532	446	325	399	422	384	415	595	340	282	322	44	425	526	51	427	207	578	175	378	42	486
4-3	8	288	55	235	246	623	375	157	452	52	348	187	394	84	56	145	266	599	139	434	122	542	498	152	202
4-4	65	35	437	241	455	247	6	389	144	444	369	501	304	86	456	205	107	323	116	510	99	466	511	385	416
4-5	343	120	9	50	260	352	439	128	124	54	243	158	248	155	39	610	585	608	297	111	106	365	147	458	403
5-1	211	109	129	165	143	126	577	332	78	435	514	166	230	523	1	589	430	320	121	491	273	159	199	308	53
5-2	163	339	245	303	547	69	562	413	520	506	609	319	381	591	550	117	465	315	615	606	160	182	489	324	148
5-3	482	61	213	235	346	354	192	350	330	468	617	462	214	342	530	262	499	30	45	601	135	316	223	376	170
5-4	76	442	386	216	196	108	249	68	25	370	603	16	490	314	535	594	28	473	221	362	616	232	366	488	295
5-5	181	58	360	290	556	338	612	234	37	3	264	60	79	277	479	275	100	552	97	443	580	554	19	268	363

Table II. C/R/I Dual-Input DEBLICOM Random Number Matrix - representing sequence of presentation of dual-paired coordinates.

Since the paired combinations in the sequence have been edited to preclude replication, each trial with a combination of two pairs is made only once under each Condition A and Condition B.

In order to eliminate differences caused by sequential tendencies the subjects will be divided into two groups. Half of the total number of subjects will be exposed first to Condition A and then Condition B; the other half, the reverse order.

One hundred training trials are to be given initially followed by 625 testing trials. Results on every training and testing trial are to be recorded immediately on the forms provided. A method of providing reinforcing feedback to the subject for use during the training trials is to be agreed upon by the experimenter and subject prior to commencement of those trials. Appropriate statistical tests will be subsequently performed at C/R/I to determine measures of the discriminability achieved under the two conditions and any difference which may result, thereby leading to a determination of the potential efficacy and feasibility of a dual-coded cutaneous communication system.

Response latencies, defined as the period from the presentation of the second pair of coded stimuli to the subject's response, will also be studied. Application of body position tags provided by C/R/I will assist in identifying the stimulus positions as well as standardizing the areas of stimulation.

VI. MORSE CODE

Of the following codes this section covers an introduction to the Morse Code. (See Chart I)

a) Morse Code

b) Braille Code

c) HAIBRI Code

d) New York Point Code

e) Moon Code

f) Hand Alphabet Signing Code

g) Tadoma Method

A preliminary literature search revealed the identity of a number of informative papers which contained relevant information.

Significantly, one of these papers,* which describes a method of multi-dimensional scaling offers valuable insight into the confusion experienced by human operators associated with their use of Morse Code in communications. This difficulty would prevail even without sensory dysfunctions. Examination of the "confusion matrix" of Figure 1 from the data analyzed shows the percentage

* J. Douglas Carroll and Myron Wish, "Multidimensional Scaling: Models, Methods and Relations to Delphi". In Harold A. Linestone and Murray Turoff (eds.), The Delphi Method Techniques and Applications. Addison Wesley Publishing Co., Reading, Mass., 1975.

MORSE CODES

INTERNATIONAL		AMERICAN
WIRELESS	CABLE	CONTINENTAL
A • —	A	A • —
B — • • •	B	B — • • •
C — • — •	C	C • • •
D — • •	D	D — • •
E •	E	E • (1 unit)
F • • — •	F	F • — •
G — — •	G	G — — •
H • • • •	H	H • • • •
I • •	I	I • •
J • — — —	J	J — • — •
K — • —	K	K — • —
L • — • •	L	L — — — (5 units)
M — —	M	M — —
N — •	N	N — •
O — — —	O	O • •
P • — — •	P	P • • • • •
Q — — • —	Q	Q • • — — •
R • — •	R	R • • •
S • • •	S	S • • •
T —	T	T — (3 units)
U • • —	U	U • • —
V • • • —	V	V • • • —
W • — —	W	W • — —
X — • • —	X	X • — • •
Y — • — —	Y	Y • • • •
Z — — • •	Z	Z • • • •
1 • — — — —	1	1 • — — — •
2 • • — — —	2	2 • • — • •
3 • • • — —	3	3 • • • — — •
4 • • • • —	4	4 • • • • —
5 • • • • •	5	5 — — — —
6 — • • • •	6	6 • • • • • •
7 — — • • •	7	7 — — • •
8 — — — • •	8	8 — • • • •
9 — — — — •	9	9 — • • — —
0 — — — — —	0	0 — — — — (7 units)
Period • • • • • •	Period	Period • • — — — • •
Comma • — • — • —	Comma	Comma • — • —
Interrogation • • — — • •	Interrogation	Interrogation — — • • — — •
Semi-Colon — • — • — •	Semi-Colon	Semi-Colon • • • • • •
Colon — — — • • •	Colon	Colon — • — — • •
Question Mark • — • • — •	Question Mark	Question Mark • • — — • — — •

CHART I

of subjects (non-sensory deprived), in a group learning the Morse Code, who judged two signals of a pair to be the same. If errorless judgements had been made, all elements on the main diagonal would be 100 and all off-diagonal entries would be zero.

In an attempt to quantify the relationships between the nature of the characters of the code elements of each pair and the probability of confusion, MDSCAL (Multi-Dimensional SCALing), a computer analysis technique, was utilized to produce the data for Figures 2 and 3.

Figure 2 is a two-dimensional plot of the data of the "confusion matrix" of Figure 1 which presents the probability of error between two coded signals as a factor inversely related to the linear distance between those two signals. The abscissa of Figure 2 is ordered approximately according to the ratio of dashes to dots in the coded signals and the ordinate approximately to the number of components in those signals. This analysis indicates that the degree of confusion between the signals of a pair can be accounted for primarily by these two code characteristics, i.e., the ratio of dashes to dots and the number of dots and dashes.

Figure 3 shows the monotonic function that resulted from analysis of the distance data from Figure 2 and the error data of Figure 1. On the abscissa are distances as computed from the two-dimensional solution shown in Figure 2 while plotted on the ordinate are the mean percent same judgements from the data of Figure 1.

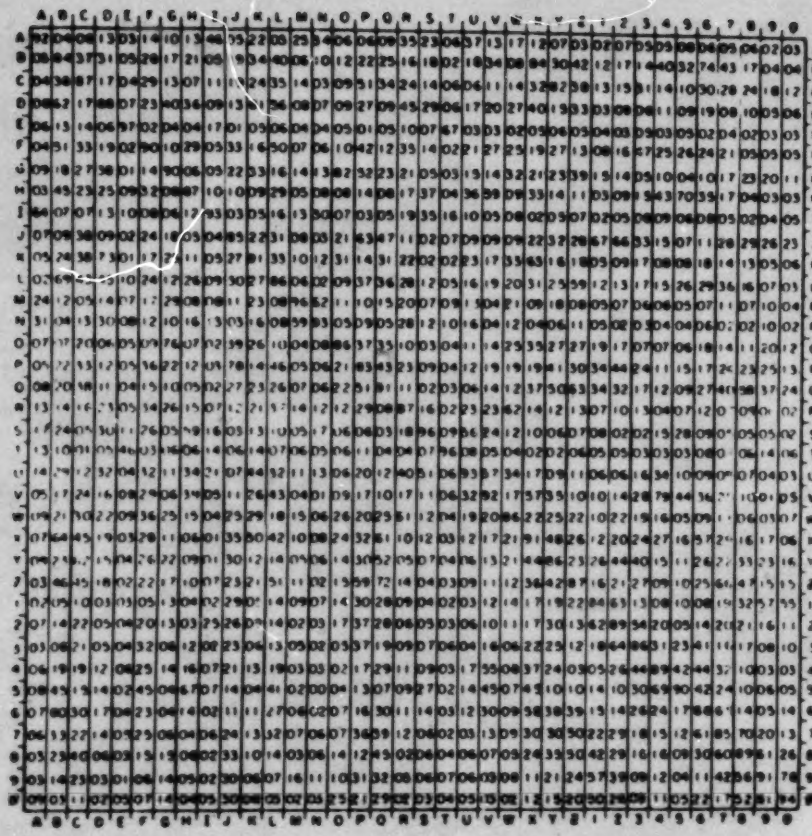


FIGURE 1. Matrix of confusabilities of thirty-six Morse Code signals (data from Rothkopf, 1957)

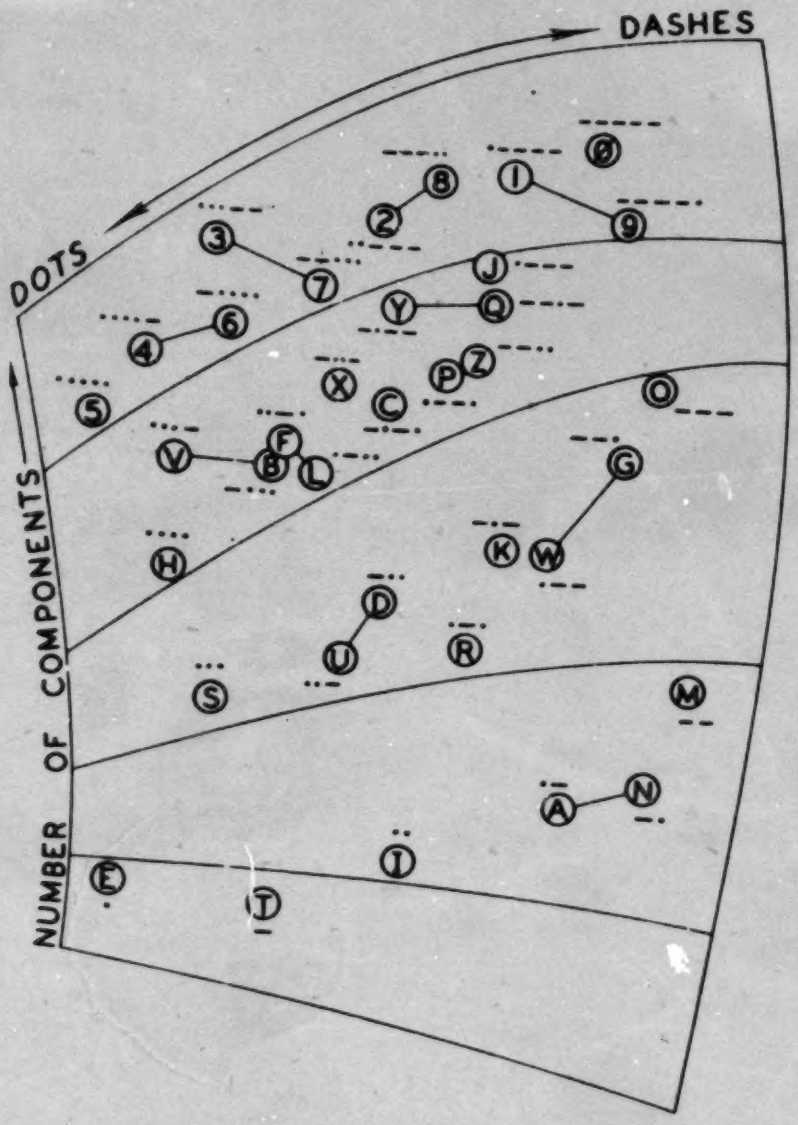


FIGURE 2. Two-dimensional configuration resulting from multidimensional scaling analysis of Rothkopf's Morse Code confusabilities (analysis by Shepard, 1963)

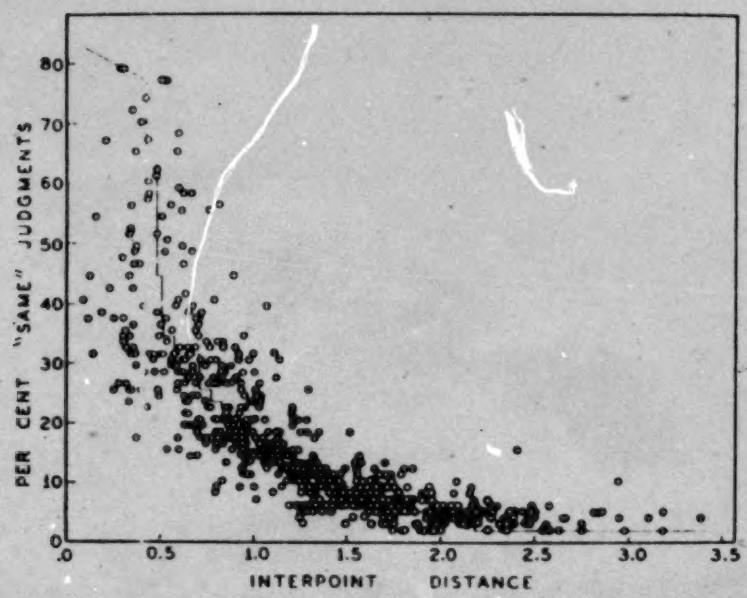


FIGURE 3. Relation between mean percent "same" judgment and interstimulus distance in the derived spatial configuration for the Rothkopf data analyzed by Shepard.

In Morse Code if the length of a dot is taken as one unit of time, then; a dash and an inter-character space are each three units long, an intra-character space is one unit long, and inter-word spaces are six or seven units long depending on the system used. (See Chart I)

An analysis of a page of text from a C/R/I report* based on the standard time ratios of dots, dashes, intra-character spaces, inter-character spaces and inter-word spaces yields:

$$\frac{dw}{dt} = \frac{1.5}{t_d} \qquad (1)$$

where: $\frac{dw}{dt}$ = rate of transmission in words per minute.

t_d = dot time in seconds.

Thus, e.g., if a dot 1/10 of a second in length is used in a Morse code transmission system the resulting rate of transmission would be 15 words per minute.

Equation (1) agrees favorably with results found elsewhere, such as the data presented by Kahn** which translates to :

$$\frac{dw}{dt} = \frac{1.3}{t_d} \qquad (2)$$

The objective here is not to establish a precise quantitative relationship between information transmission rate and dot length for Morse Code but to show that the achievement of acceptable rates dictates the use of short dot lengths. This places limitations on information transmission rates using cutaneous stimulation modes.

* Kafafian, 1968, page 1.

**Kahn, "The Code Breakers", pg. 741.

It should be noted that when a parameter other than time duration is used to allow one to discriminate between dots and dashes an increase in information transmission rate can be realized. If in a cutaneous Morse Code system, e.g., two different stimulus sites are used to present dots and dashes of equal time duration rather than presentations at a single site with time duration discrimination, analysis of the same text material that led to (1) yields:

$$\frac{dw}{dt} = \frac{1.86}{t_{dd}} \qquad (3)$$

Where : t_{dd} = dot time and dash time in seconds.

Comparison of (3) with (1) shows that a 24% improvement in transmission rate can be realized by the use of a spatial discrimination system over that which a time discrimination system will yield for a given dot period. To our knowledge this latter approach* has not been tested. It may be worthwhile to determine if it has, and if not, to consider continuation of the original Foulke and Brodbeck** work with this in mind.

Analysis of this same page of text leads to the conclusion that DEBLICOM coding should result in more than twice the information rate provided by Morse Code in an electrocutaneous or vibrotactile stimulation system as indicated by:

$$\frac{dw}{dt} = \frac{3.1}{t_d} \qquad (4)$$

Comparison of (4) with (1) shows 107% improvement in transmission rate through use of the DEBLICOM code.

* Private Communication - H. Kafafian and E. Foulke (1976).

** Foulke, E., and Brodbeck, A. A. "Transmission of Morse Code by Electrocutaneous Stimulation," Psychological Record. 1968 (18), 617-622.

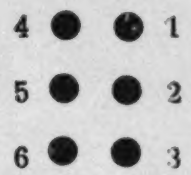
VII. BRAILLE CODE AMBIGUITIES

The possible ambiguities of the six-dot Braille code are shown in Table III, (Kafafian, 1968) * The tabulation shows the 31 possible pattern ambiguities out of 63 total combinations. Thus, approximately 50% of the patterns have identical structure.

The use of Braille in acquiring information is limited to persons having above average cognitive ability and keen tactile discrimination capability. There are many reasons that preclude use of Braille by older persons who are blind. These reasons include their use of less difficult means to acquire information, i.e., volunteer or professional readers, tapes, records, radios and 'talking books" which are made available through the Library of Congress on a no-charge basis. The limitations are also due to the individual's tactile perception capability and other reasons which preclude even highly motivated and intelligent persons from using the Braille code. A punctographic HAIBRL ** code that is unambiguous will be covered in subsequent progress reports.

* Kafafian, H., "Study of Man-Machine Communications Systems for the Handicapped", 1968.
** Ibid.

The following illustrates the six-point Braille cell wherein the numerals identify the points or "dot" positions first as embossed, and second, as they appear on the opposite or reading side of the writing material.* Braille pattern ambiguities are shown in Figure III.



Embossing Side

Reading Side

Dot Combinations	Possible Ambiguities	Single-Dot or Dot Combinations which Yield Similar Patterns
Single	6	1 2 3 4 5 6
Dual	13	1,2 2,3 4,5 5,6 | 1,4 2,5 3,6 | 1,5 2,6 | 4,2 5,3 | 1,3 4,6
Triple	10	1,4,5 2,5,6 | 4,5,2 5,6,3 | 5,2,1 6,3,2 | 2,1,4 3,2,5 | 1,2,3 4,5,6
Quadruple	2	1,4,2,5 | 2,5,3,6
Total: 31 (of a total of 63 possible combinations)		

FIGURE III. Possible ambiguities in the six-dot Braille cell.**

* Ashcroft, S.C., Henderson, F., Programmed Instruction in Braille. Stanwix House, Inc. Pittsburg, Pa. p. 11-14, 1963.

** Kafafian, H. , "Study of Man-Machine Communications Systems for the Handicapped" pg. 20, 1968.

VIII. FUTURE ACTIVITY PLANS

The following, Part I & II and the Program Schedule represent the areas to be concerned in the forthcoming work periods.

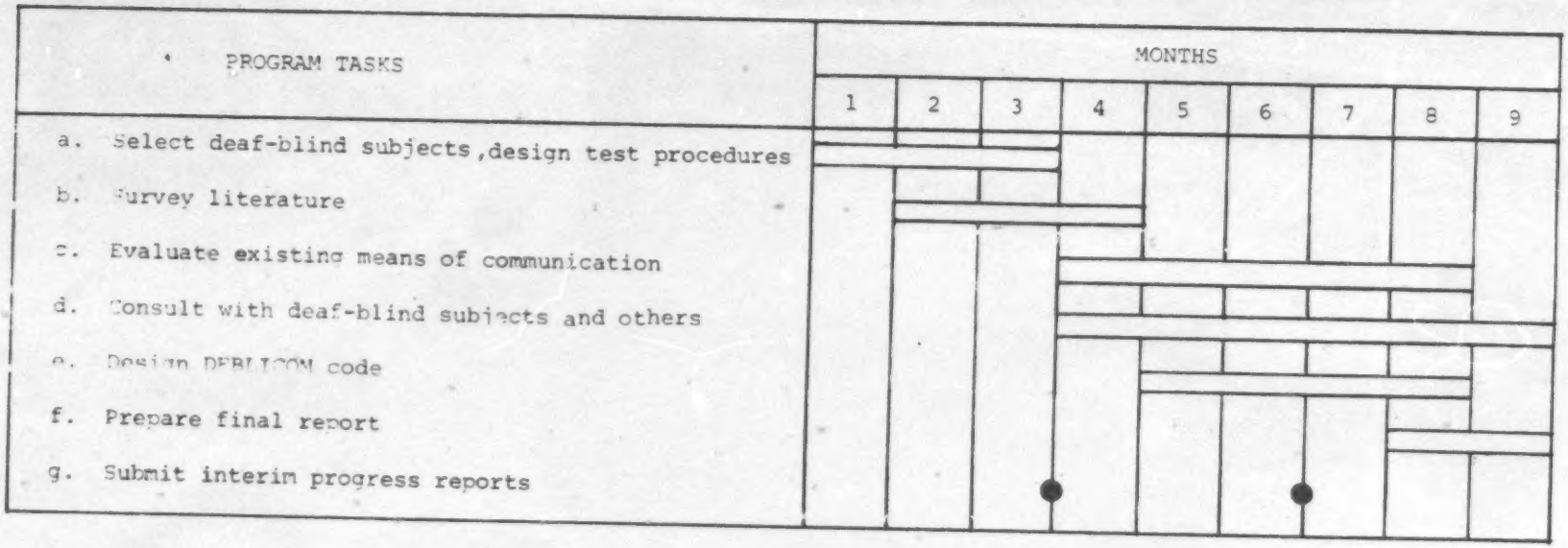
Part I

1) Describe the DEBLICOM program and its objectives in detail to the Field Center personnel cooperating in the study.
2) Train the test administrators.
3) Identify and approve selection of subjects.
4) Commence testing.
5) Collect data.
6) Analyze data.
7) Prepare report.

Part II

Study the following alternative codes in depth:

a) Body writing or signalling
b) Hand or machine signing
c) Telegraphic and/or machine codes, e.g., Morse, binary
d) Typing, "Cybertyping", and so on
e) Cursive writing
f) Vocal-musculature/tactile
g) Punctographic, e.g., Braille, HAIBRL
h) Semaphore
i) Palpable cutaneous non-coded systems, e.g., "Vibratese", TVSS
j) Palpable coded devices, e.g., DEBLICOM



PROGRAM SCHEDULE

APPENDIX A

C/R/I DEBLICOM Working Paper
SUBJECT: Background

Formal educational systems and understanding of the deaf-blind commenced in the United States around 1837, when Laura Bridgmen entered the Perkins School for the Blind. About 50 years later, parents of the late Helen Keller learned about Dr. Samuel Bridley Howe of the Perkins School from Alexander Graham Bell, the great inventor. Helen Keller's outstanding achievements and the accomplishments of her teacher, Anne Mansfield Sullivan, continue to stand out as an historic milestone in man's progress towards communicating with the deaf-blind.*

Even though it has been demonstrated that information can be conveyed to and from a deaf-blind person through use of the manual alphabet, signing, reading and writing cutaneously and through use of a "reader's" hand or hands on the speaker's face and throat area, there still remain many critical problems related to diagnosing, rehabilitating, and improving the communication and control needs of the deaf-blind.

"There is disagreement already at the level of diagnosing and labeling. For instance, Rimland compared the diagnoses for 445 children, as given by the doctor who was consulted first, with a 'second opinion'. If the art of diagnosis has any objective basis, there should be a positive correlation between first and second opinions. In fact, as Rimland points out, there is not a trace of such a correlation - the diagnoses are practically random (Table II).

What doctors have been saying to the parents is little more than, 'You are quite right; there is something wrong with your child'".** See chart I (Rimland Chart)

Present-day teaching methods for the deaf-blind are essentially random and depend on the individual teacher's particular style of presenting language and concept information. There is usually a teacher-student training period of many years which requires patience and compassion on the part of both student and teacher. This relationship develops into a bond wherein the student depends on those with whom he has been in close contact to the extent that the student's ability to communicate to the outside world is something diminished. Had the student been trained to use man-machine systems he could have had access to devices and computer terminals which are equipped with appropriate interfaces and cutaneous or tactile output mechanisms.

* Keller, Helen, "The Story of My Life", Dell Publishing, 18th printing, February, 1974,
**Tinbergen, Nikolaas, "Ethology and Stress Diseases" Science, Vol. 185, July 5, 1974, pp. 20-27.

Memorandum: DEBLICOM Working Paper
Subject: Population of Deaf-Blind Persons in the United States (1974)

Age Group	Number
0 - 2 years	60
3 - 5 years	415
6 - 8 years	803
9 - 11 years	1,438
12 - 14 years	413
15 - 17 years	439
18 - 21 years	315
over 21 years	123
age unknown	90
Total, all ages receiving some service	4,096
Recorded additional deaf-blind not presently receiving service	318
Never received service*	947
TOTAL	5,361

*Based, in part, on private communications, Haig Kafafian, C/R/I and Dr. Edgar Lowell, The John Tracy Clinic, Los Angeles, California, June, 1974.

The Regional Centers for Deaf-Blind Children define a deaf-blind child as:

> "...children who have auditory and visual handicaps, the combination of which causes such severe communication and other developmental and educational problems that they cannot properly be accomodated in special education programs solely for the hearing handicapped child or for the visually handicapped child."
> Dantona, Robert, Demographic Data and Status of Services for Deaf-Blind Children in the United States

FIRST OPINION	SECOND OPINION: Autistic	Infantile autism or early infantile autism	Childhood schizophrenia	Emotionally disturbed or mentally ill	Brain or neurological damage	Retarded	Psychotic	Deaf or partially deaf	Total Subjects
Autistic	33	5	53	18	23	51	10	7	200
Infantile autism or early infantile autism	1	10	6	0	4	6	0	2	29
Childhood schizophrenia	17	3	1	2	8	1	0	0	32
Emotionally disturbed or mentally ill	12	2	4	2	9	13	3	0	45
Brain or neurological damage	14	3	2	5	4	15	0	1	44
Retarded	21	2	6	18	16	5	2	2	72
Psychotic	4	0	1	1	2	2	0	0	10
Deaf or partly deaf	4	1	0	2	0	5	1	0	13
Total Subjects	106	26	73	48	66	98	16	12	445

CHART I

COMPARISON OF FIRST AND SECOND OPINIONS ABOUT 445 CHILDREN SHOWING SEVERE BEHAVIOR DISORDERS (FROM RIMLAND) (NOTE THAT NO CORRELATION APPEARS BETWEEN "FIRST" AND "SECOND" OPINIONS)

C/R/I DEBLICOM Working Paper
SUBJECT: Some Causes of Deafness-Blindness and Deafness and Blindness

Late Prenatal Syphilis

Examples of late prenatal syphilis representing an active tissue response to earlier "sensitization" are; interstitial Keratitis, eighth nerve deafness and Cluttons joints.

Interstitial Keratitis has its onset between 3 and 20 years of age, most commonly between 6 and 14. It is an intense inflammatory vascular infiltration of the cornea accompanied by an iritis, which may be followed by a dense cicatricial scar producing blindness. Although usually bilateral it may come in one eye before the other.

Tuberculous Meningitis

It is usually the result of the breaking down of a focus in the brain with dissemination of organisms in the spinal fluid.

It is seen in all age groups, but most patients are under the age of 5 years, the peak incidence being soon after the end of the first year. Residual mental or physical damage occurs most frequently in the younger infants and those diagnosed late.

The sequelae include convulsions, mental retardation, blindness which is often reversible, deafness which is permanent when it occurs.

Bilateral Atresia of the Exterior Auditory Canal

This may occur alone or in association with deformities of the middle and inner ear. Bilateral atresia of the external auditory canal produces deafness, which in turn interferes with normal development of speech.

Tay-Sachs Disease (Infantile Familial Anaurotic Idiocy)

The symptoms are usually first noted at about 4 to 6 months of age when it is observed that the infants development, previously normal, appears to slow and then stop. Initially, these are apathy, muscular hypotonia, loss of previously acquired functions and failure of vision with an inability to follow or fixate. The disease is inherited as a simple autosomal recessive trait having a high degree of pentrance and little variability in expression. No favorable specific therapy is available.

Niemann-Pick Disease

The salient features are developmental arrest followed by progressive cerebral deterioration not unlike that seen in Tay-Sachs Disease, hepatosplenomegaly, and blindness. Death usually occurs before the third year.

Cytomegalic Inclusion Disease is caused by a cytomegalovirus. Patients who survive the neonatal stage of the disease may develop mental retardation, convulsions, motor disabilities, spasticity and paralysis, as well as microphthalmia, blindness and deafness. The most frequently involved organs are the salivary glands, liver, spleen,lungs, brain, kidney and adrenal glands.

Measles Encephalitis - The incidence varies considerably from outbreak to outbreak. Approximately 10 % of the patients with measles encephalitis die while in the acute stage of the disease. However, the general tendency is toward recovery. Unfortunately, approximately 20% of the patients who survive the acute state suffer irreversible damage. The sequelae range from changes in personality, to cerebral ataxia, to nerve deafness and permanent injury to the optic nerves and so on.

Poliodystrophy- Poliodysplasia (Progressive Degeneration of Cerebral Gray Matter).

This disease is probably due to a variety of causes; it is not likely that the familial forms,the postencephalitic, post-epileptic, and traumatic cases, share a common etiology. The cases reported show a great diversion of signs and symptoms and striking variability of duration age and onset.

From the clinical point of view progressive mental deterioration, seizures, myoclonic twitching followed by progressive spasticity blindness and often deafness should lead to the suspicion of progressive degeneration of the cerebral gray matter. Optic atrophy, abnormal involuntary movements, and ataxia, occur.

Hurler's Disease - A severely deforming hereditary syndrome affecting virtually all organs of the body. Corneal clouding and deafness occur frequently.

Schilder's Disease (Encephalitis Periaxialis Diffusa).

Schilder's Disease shows an extensive demyelination of the cerebral white matter. The age of onset may be at any time past infancy with a peak incidence between the ages of 5 and 10. The onset is acute, often with seizures , progressive visual loss, and gait disturbance. There is progressive dementia, frequent loss of hearing, aphasia and paralysis. The frequent loss of vision is attributable to cerebral as well as optic nerve demyelination with a complex picture of cortical blindness and optic neuritis. Prognosis is fatal and treatment unknown.

Alper's Disease

Diffuse cerebral degeneration in infancy with extensive neuronal loss. The onset is withconvulsions and myoclonus followed by progressive mental and motor involvement, often associated with cortical blindness and deafness.

C/R/I DEBLICOM Working Paper
SUBJECT: Some Causes of Deafness-Blindness

CATEGORY	CAUSES		
	DEAFNESS & BLINDNESS	BLINDNESS	DEAFNESS
I Congenital Deaf-Blind	Hurler's Syndrome Usher's Syndrome Congenital Rubella Late Prenatal Syphilis		
II Adventitious Deaf-Blind	Measles Encephalitis Tuberculous Meningitis Schilder's Disease Poliodysplasia Alper's Disease Cytomegalic Inclusion Disease other reasons ‡		
III Congenital Blind Adventitious Deaf		Hypervalinemia Tay-Sachs Disease*	Refsum Syndrome other reasons‡
IV Congenital Deaf Adventitious Blind		Nieman-Pick Disease* Retinitas Pigmentosa other reasons ‡	Hypervalinemia Bilateral Atresia of the External Auditory Canal

* usually fatal disease

‡ Reasons such as improper medical and/or surgical treatment, improperly conducted experiments, explosions, war, torture and irreversible damage due to self-inflicted wounds or injuries caused by others.

CHART II

C/R/I DEBLICOM Working Paper
Subject: Usher's Syndrome

The paper on Usher's syndrome states that there are about 6,000 people who are deaf but not blind, who will later become blind too, thus increasing the segment of the deaf-blind population. The job of training these people should be considerably simpler than the procedure offered by DEBLICOM for congenitally deaf-blind children. Not only will it be possible to train them in the use of the harness and mobility aids before they lose their vision, they will be able to select messages for the display that reflect their individual needs and interests. The fact that the onset of blindness does not occur until late adolescence or early adulthood, becoming incapacitating (usually) between the ages of 30 and 40, means that most of these subjects will have acquired useable techniques of communication.

Two studies (Fraser's and Hallgren's) are mentioned in this paper in which the syndrome was reported as occurring in 3 cases out of 100,000 and the author enters this data in Table 1 as "0.3%". This should, of course, be 0.003%. Some typos appear in the report but are not significant to the main purpose of the paper.

Early diagnosis is possible and is made considerably easier by the fact that Usher's is associated with congenital deafness. Thus if the congenitally deaf (about 1/3 of the school-aged deaf) are given a careful ophthalmic examination, the chances of early detection are excellent. The syndrome is found in 5 to 10 percent of the congenitally deaf. Vernon mentions that because of the presumed metabolic or higher CNS nature of the syndrome, there is higher incidence of retardation and psychosis among those with Usher's. This retardation is usually slight and typically is not serious enough to interfere with communication. Some individuals with Usher's, in fact, achieve superior scores on the Wechsler or Leiter. More serious, however, is the frequency of mild to severe aphasia among these individuals. The simplicity of the DEBLICOM code, however, should make the system useable in all but the most extreme of these cases.

In summary, there appears to be a large number of potential DEBLICOM users-individuals with Usher's syndrome-who could be diagnosed and trained in the system's use before losing their vision.

C/R/1 DEBLICOM Working Paper
SUBJECT: Considerations for Cutaneous Stimuli

The skin responds to several forms of stimulus energy and combinations thereof. The integument of the body is complex and contains a variety of neural receptors. Sensation for static pressure and low frequency (< 50 Hz.) vibration is believed to be due to stimulation of the dermal ridge receptors. The much greater vibratory sensitivity of the skin to higher frequencies (200Hz. to 400Hz.) is believed to be due to stimulation of the Pacinian corpuscles. The skin also contains receptors which are sensitive to thermal and chemical stimulation. These are not as well understood. As with the eye (electrical phosphenes) and the ear (the electrophonic effect), the skin may be stimulated electrically. Therefore when considering how to use a system of skin stimulators for communicating with the deaf-blind a variety of alternatives exist. The decision to use one or another must be based, therefore, on such considerations as reliability, portability, convenience, cost, speed and so on.

Let us therefore begin with some of the alternatives which have been considered. The use of the general chemical sense raises many problems. Not only would it be difficult to develop a system for irrigating the 16 DEBLICOM stimulus positions selectively with chemicals to which the skin is sensitive, but there exists the real possibility that repeated chemical stimulation could be injurious to the user.

The second alternative to be considered was thermal stimulation. Geldard and Sherrick have developed a thermal stimulator which uses expanding gas for cooling and a resistive electrical element for heating. This device is slow and the gas canisters needed for portability would be bulky and awkward. An alternative method of cooling might consist of retaining the resistive element for heating and using a Peltier thermoelectric effect device for cooling. The Peltier effect is a drop in temperature which accompanies the flow of current through a junction between certain pairs of dissimilar materials. This again, however, would be slow and could be awkward to use.

The next alternative to be considered was electrical stimulation. Although this could provide a fast and lightweight system, there are factors which argue against its use. The first involves useable range. There is far less range between the threshold of sensation and the threshold of pain for electrical stimulation than for vibratory stimulation. In addition, the electrical properties of the skin vary considerably from one person to another and from one position to another and even from one position over time. (Changes in skin resistance over time provide the major index of emotional arousal used by police polygraphers). There is evidence that the stimulus can be controlled through the use of concentric anular electrodes to control the spatial gradient of e.m.f. and a constant current source to compensate for electrical changes. However considerable work would have to be performed before a reliably painless system

could be developed.

The above considerations leave us with vibratory mechanical stimulation as a practical alternative. The literature contains four approaches to mechanical stimulation of the skin. We have ruled out two of them. The first to be rejected for use in the prototype, DEBLICOM harness was charging the subject and using an electrode's attraction or repulsion to stimulate the skin. The stimulus in this case does not appear to be spatially well localized. (The safety problem involved with high voltage could be readily solved with current limiting and both electronic and electro-mechanical fusing).

The second approach to vibratory stimulation was the servovalve modulation of air jets. Although Rogers was able to achieve pulse rates up to 60 Hz. using this method, it would apparently be expensive and difficult to develop a portable system.

This leaves two approaches for us to investigate. One of these consists of the use of the "voice coil" approach such as the device developed by Goodman's Ltd. and now sold by Pye-Ling Inc. It is reliable, rugged, and effective. Its chief disadvantages are its weight (which for an array of 16 vibrators might be considerable), the fact that its mass precludes rapid attacks and decays, and the somewhat large current it draws.

It appears that one of the most satisfactory transducers is most probably, the reed bimorph piezoelectric transducer. It is light in weight, can be designed to resonate at the frequencies to which the skin is most sensitive and draws little current. Care must be given to the manner bimorphs are mounted since they are somewhat fragile . Current limiting and fusing techniques would prevent any shock hazard associated with the voltages needed to drive a set. This transducer will be among the first to be investigated by C/R/I.

C/R/I DEBLICOM Working Paper
SUBJECT: Conference of DEBLICOM - Part I

The first session of a two-day conference was attended by Mr. Gregory Apkarian, CYBERCOM instructor Mill Swan School, Worcester, Massachusetts and Ms. Rosalyn Monat, Director of Speech and Hearing, Coastal Center, Ladson, South Carolina. They were participating in the C/R/I seminar in order to give us their ideas about DEBLICOM and the benefit of their experience.

Much of the initial discussion was general. Mr. Apkarian told us of how very successful he has been in using the CYBERTYPE system with children having muscular dystrophy. He suggested that we had left out several phrases on our initial list of DEBLICOM messages which he had found very important for the children with motor handicaps with whom he works. He suggested we replace some of the less important items on the original list with "I love you", "I can", "stop", and "more". The discussion then focused on DEBLICOM.

Ms. Monat who directs the education of many deaf-blind children told us of her work with severely retarded deaf-blind children. Her procedure was then outlined. Initially the child is brought into the training center and given a period of adaptation. This consists of placing the child on a toilet according to a fixed schedule and extinguishing emotional reaction to the situation and to tactile stimulation. She then introduces the sign for "eat" in sign language. She uses operant shaping of the response and rewards the desired behavior with food. She then introduces other basic or "core" words. The children are taught signs for "more", "yes", and "no", then words associated with action,"ball", "toilet", "shoes". This is followed with a few direction words, then some more functional objects in the environment are added. Ms. Monat stated that the children she worked with are so severely retarded that many learn"only a word a year".

It was repeatedly stressed that C/R/I prepare an instructional guide or manual. The manual would tell how to formulate clear educational objectives in behavioral terms. It should show how to convert the objectives into the conditioning, shaping, discrimination training and other procedures needed to bring about the objective. By being sufficiently explicit, this will reduce the need for specially talented teachers according to Ms. Monat.

One constraint was mentioned. The training will have to rely exclusively on the use of positive reinforcement since some of the States have laws which preclude aversive control or punishment to be used in institutions.

C/R/I DEBLICOM Working Paper
SUBJECT: Transfer of Training

Transfer of training is an important factor with the DEBLICOM system*. It is expected to accelerate the learning of the dual-input finger code once the stimulus patterns have been learned. It should also allow us some flexibility in the placement of the vibrators. This latter problem has been studied by Foulke. Using Braille as the tactile code he measured the transfer from training with the index finger to reading with the third, fourth, and fifth fingers. Although reading time and error rate tripled when the 5th finger was used, there was still considerable transfer. Transfer was greatest between the index and third fingers, less between the index and fourth and least between the index and fifth.

Although reading Braille with the fingers is not the same as reading vibration patterns on the body, the tasks are similar enough to justify the assumption that transfer would permit moderate changes in the position or spacing of the vibrators. This transfer should be almost complete if changes are introduced gradually.

The learning of the dual-input keyboards should proceed quite rapidly once the vibrator pattern code has been learned. In this case the one-to-one mapping keys and vibrators makes it only necessary to learn which key goes with which vibrator. Although transfer would be greatest if the keyboard and the body vibrators had the same configuration, the simplicity of the task makes this really unnecessary.

Of course there are other advantages of Kafafian's dual-input two-stimulator code. Geldard and Sherrick found that position discrimination among multiple stimulus patterns is better for two vibrators than for one or three or more; and Warm, Clarke, and Foulke found recognition time to increase rapidly with an increase in the number of elements in a tactual display.

* The ability to recognize letters or patterns drawn on the back is one striking example of transfer. Other examples include improvement in the skill of one hand after practice on another, and so on.

C/R/I DEBLICOM Working Paper
SUBJECT: Diagram of DEBLICOM Command Code Reduced Key Interfaces